

1 INFLATABLE RESTRAINT ASSEMBLY FOR VEHICLES

2 Field of the Invention

3 This invention relates to an inflatable restraint system primarily designed for use
4 within a motor vehicle to protect occupants when the vehicle is involved in an accident,
5 and specifically, a collision or other type of crash or impact. The inflatable restraint
6 system comprises a central processing unit or other processor operatively connected to
7 both a sensor assembly and a variable valve assembly in order to initially inflate and
8 actively regulate pressure within a first and second plurality of chambers, respectively
9 defining impact absorption and impact resistance zones, disposed on the interior of each
10 of one or more inflatable members mounted at strategic locations adjacent intended
11 occupant positions within the vehicle.

12 DESCRIPTION OF THE RELATED ART

13 Every year, thousands of people in the United States alone are involved in motor
14 vehicle accidents, many of which result in the death of one or more occupants and/or
15 severe bodily injury to others. Aside from the devastation and havoc these accidents
16 cause in people's lives, they also result in costs of over five billion dollars annually to the
17 insurance industry, health care industry, health care providers, the federal government,
18 public health agencies and many others. It should, therefore, be clear that the cost of
19 morbidity (long term injury consequences) to the automobile and insurance industries is
20 staggering.

21 Most current methods of reducing injury are predicated upon the principle of
22 safety restriction and immobilization using seat belts and the use of single or multiple air
23 bags. With regard to the inflation of the air bags in an emergency condition, the in-filling
24 pressure dynamics are known to cause direct chest, face, eye, and sometimes brain and

1 spinal injury when they are deployed against the passenger in an attempt to deal with
2 impacting forces only from the view point of the passive absorption of such forces.
3 Moreover, known air bag structures and designs are inflated towards the occupant.
4 Accordingly, with regard to conventional seat belt construction, diagonal chest belt
5 restraints, are disposed such that they have a tendency to rub across an anterior portion of
6 the neck. Medical publications report complications of carotid artery thrombosis and
7 subsequent stroke from blunt trauma to the neck from seat belts. Similarly, lap seat belts
8 are known to cause pelvic and extremity injuries as well as blunt abdominal trauma. The
9 fact that such air bags and seat belts save lives and reduce injury is not in question.
10 However, most vehicular injuries, particularly those occurring at high speeds are not
11 entirely predictable or preventable, especially with the use of these known or
12 conventional devices.

13 The mechanisms which cause injuries in humans involves the summation of
14 deceleration forces, and in particular those linear momentum, angular momentum and
15 torque-rotation, vertex-loading, centripetal and centrifugal coefficient restitution forces
16 and spinal "crunch" forces. Most of these can not be prevented because they occur
17 probably within the first three seconds of low velocity accidental impact, and within the
18 first 150 milliseconds of high velocity impacts, wherein the effect of such forces is
19 completed, usually within 250-350 milliseconds. Thus, early on, the forces have already
20 acted to produce injury and conventional seat belts and air bags become passive recipients
21 of those forces, reducing somewhat but not them actively opposing them.

22 Accordingly, it should therefore be recognized that some injuries are due more to
23 linear momentum and deceleration forces, and others to angular momentums with
24 deceleration forces. Added to these are a combination of torque forces, centrifugal and

1 centripetal forces and the "crunch" forces due to spinal loading. Moreover, all of these
2 forces are summated by the time the air bag is impacted by the body of the occupant. As
3 forth above, the result is that the most the belt restraints and air bags can do, even when
4 cooperatively reacting with one another, is to passively absorb such forces. When the
5 summation of these forces are greater than the ability of the human body to tolerate them,
6 tissue deformation occurs with the resulting injury. Calculating these forces is difficult to
7 uncertain because the calculations must take into account angles of deflection, balance
8 and the elasticity of human tissue. For this reason, I restrict the discussions below of
9 scientific principles to simpler concepts and standard formulas of physics and biophysics
10 for conceptual understanding.

11 None of the injuries, which occur in motor vehicle accidents, are totally
12 predictable or preventable since the exact time or circumstances of a motor vehicle
13 accident are not always known or predictable. In other words in most instances where
14 serious accidents are under consideration, the current state of the art permits incomplete
15 reduction of injury forces with the result being that total prevention remains elusive.
16 Similarly, no two human bodies react in the same way to injury forces. In other words,
17 the variables over which there is no control are significant. To date, there is no known
18 way to totally prevent injury, particularly in high velocity conditions. There is however, a
19 better way to reduce and control the harm caused by the summation of forces of
20 deceleration, which cause injury.

21 As set forth above attempts to protect the occupants in a motor vehicle have for
22 the most part included seat belts, also known as restraint harnesses and more recently,
23 inflatable air bags. Such devices are most certainly a step in the right direction, and when
24 used properly, have saved a tremendous number of human lives. Even so, both seat belts

1 and air bags suffer from distinct disadvantages. By way of example, harness restraints
2 including lap belts, chest belts, etc., limit the forward or lateral motion of the body's
3 acceleration caused by an impact, but in doing so, such restraints cause the base of the
4 neck to act as a fulcrum or axis of rotation-flexion-extension to further accentuate the
5 force of acceleration of the head on the neck. More specifically, when there is a collision,
6 the motor vehicle is usually stopped by the impact, but the forces applied to the body and
7 restrained by the seat and/or lap belts are nevertheless also acting to set the head in
8 motion upon the neck, leading to impact injuries caused by a collision of the head against
9 the front or side window, ceiling of the car or steering wheel. Thus, the common
10 mechanism of injury to the brain, spine and/or spinal cord in head-on collisions is an
11 acceleration - deceleration of the head, and the neck, causing a hyperflexion-
12 hyperextension injury, whereas in broad-side collisions, the head is accelerated to the side
13 or laterally causing a lateral- flexion injury.

14 Most modern day motor vehicles use a combination of restraint harnesses and
15 inflatable air bags, which typically, inflate during a collision in an extremely rapid
16 manner from the steering wheel and/or front console area of the vehicle and towards the
17 occupants. Thus, inflatable air bags are intended to cushion the occupant as he or she is
18 thrust forward, under the forces being applied during a head on collision, and impacts the
19 air bag. While the provision of air bags on modern day motor vehicles has certainly
20 brought down the mortality rate, meaning that more people can survive the violent forces
21 of a head on collision, the injury rate is thought to have increased, meaning that survivors
22 of these and other types of crashes often suffer from serious head, neck and/ or spinal
23 cord injuries. That is because by the time air bags are deployed, the forces caused by the
24 vehicular impact are already acting on the body and, as set forth above, cause acceleration
25 - deceleration of the head on the neck as well as of the torso on the hip. In some instances,

1 air bags have even been reported to cause nasal and facial fractures and, in extreme
2 circumstances, result in the forcing of bone fragments into the brain. Further, the
3 direction of air bag discharge is almost invariably towards the occupant and can promote
4 hyperextension injury to the spine or posterior head injury. This is prevalent and can be
5 particularly dangerous in elderly persons with osteoporosis, a thinning of the bones with
6 age due to calcium depletion.

7 There have been some attempts to improve the protection for motor vehicle
8 passengers, which have primarily been directed to the deployment of air bags from
9 multiple locations within the vehicle, in order to surround an occupant with restraints.
10 Such attempts have found favor and are promoted primarily by some European car
11 manufactures, most notably those which proclaim the benefits of "side air bags." While
12 adding to the expense of the automobile, these and other multi-location deployment
13 systems have been offered in response to an increased demand to solve the problem of
14 multiple trauma injuries, prevalent in impact accidents. Further, such attempts reflect the
15 desire of the motor vehicle industry to control and find a solution to problems that
16 continue to cause death, disability and injury at an ever increasing rate. Such attempts are
17 also a positive step forward in the effort to reduce death and serious bodily injury during
18 accidents due to direct impact to the vehicle. However, even air bags that deploy from
19 the side or other location in a motor vehicle do not effectively address the forces at work
20 during an impact that cause acceleration of the head relative to the neck, and/or the neck
21 relative to the torso, and therefore, the problem of brain, spine, neck and torso injuries
22 resulting from such accidents have also not been adequately addressed.

1 SUMMARY OF THE INVENTION

2 Accordingly, there remains a need in this art for a restraint assembly which is
3 designed and structured to more actively intercept at least the head and neck motion of an
4 occupant riding in a motor vehicle undergoing a collision or other impact. More
5 specifically, there is a need for an inflatable restraint assembly which *attempts to actively*
6 *oppose* the forces of impact between a passenger and an air bag, sufficiently to diffuse
7 such forces by applying an equal and opposite force, while buffering the passenger's
8 impact, and thereby, reducing dynamically and actively, the range of motion of the head,
9 neck and torso, caused by the impact as well as acceleration -declaration. Any such
10 improved restraint assembly developed would preferably also utilize at least two,
11 oppositely disposed and pressure sensing inflatable members, each having a plurality of
12 chambers, and further, through the application of microcomputer-microprocessor
13 technology, initiate a positive gradient increase in pressures to some, but not all chambers
14 of the pressure sensing inflatable member, for the specific purpose of slowing the
15 acceleration - declaration forces at work on an occupant's body, while applying an equal
16 and opposite force to the force of impact of the occupant's body with the other(s) of the
17 inflatable members. Any such improved restraint system should further include a
18 plurality of inflatable restraint devices or bags strategically located at various points
19 throughout the passenger compartment, including but not necessarily limited to the
20 ceiling, door post and seat belts, so as to provide as much surrounding or "global"
21 protection as possible, with the goal being to significantly reduce injury by a reduction of
22 the forces exerted on the occupant's body during impact type accidents. In addition, any
23 such improved restraint assembly developed should also overcome the long existing
24 problems of known restraint systems through the ability to actively oppose impact forces
25 "intelligently" through a series of dynamic pressure measurements conducted in response

1 to the acceleration-deceleration to the various portions of the passenger's body as the
2 body impacts substantially oppositely disposed, but cooperatively positioned, inflatable
3 members.

4 In addition to the above, any such improved restraint assembly developed should
5 have the capability of storing data for determining and recalling related information, such
6 as predicted speed of impact and a record of pressure sensing data. Such data could be
7 correlated with post injury medical findings to determine, over a period of time, what
8 impact and pressure ranges cause disabling injury as versus those impact and pressure
9 forces which are only suspect at the present time. Such memory capabilities would serve
10 as a meaningful tool of analysis and benefit to the medical and insurance industries,
11 among others.

12 Finally, a preferred restraint assembly should also incorporate the use of a
13 restraining harness which is adjustable to accommodate occupants of various sizes and is
14 structurally modified to better protect, in terms of restraint, various portions of the
15 occupants body. In addition, the restraining harness may further include at least one
16 inflatable member which may be structured as described above and when inflated is
17 directed outwardly from the restraining harness and the frontal area of the occupant.

18 The present invention is intended to address these and other needs which remain
19 in the art and is directed towards an inflatable restraint assembly that is primarily, but not
20 exclusively, designed for use within a motor vehicle. The restraint assembly comprises a
21 plurality of inflatable members, which are strategically mounted throughout the interior
22 passenger compartment of the vehicle at locations adjacent to an intended occupant
23 position, such that deployment of one or more of the inflatable members will provide
24 maximum protection to an occupant, when located in one of the intended positions

1 normally occupied. Further, it is emphasized that while a detailed explanation of the
2 structural and operative features of the present invention will be described relative to at
3 least one inflatable member, one feature of the present invention is the cooperative
4 positioning of two or more of such inflatable members, so as to be “globally” oriented or
5 collectively disposed in at least partially surrounding, alternative intercepting relation to
6 each of the occupants. Such cooperative and collective positioning of a plurality of the
7 inflatable members of the present invention are, in certain instances, specifically intended
8 to significantly reduce injury to the occupant caused by an excessive acceleration or
9 forward motion followed immediately by a rebounding deceleration, which often occurs
10 through the use of conventionally known air bags or inflatable restraint devices. In such
11 known systems, the conventional air bag structure is forcibly inflated resulting in a
12 deployment of the bag in a direction substantially towards the occupant. As a result, the
13 occupant frequently suffers damage upon impact with the conventional air bag and quite
14 frequently suffers hyperextension and/or hyperflexion type injuries, due to a forceful
15 forward and backward acceleration of the head on the neck and/or the body torso upon
16 the lower back and hip.

17 In order to avoid these types of well recognized problems associated with the use
18 of conventional inflatable restraint systems and structures, the present invention utilizes a
19 central processing unit or other type of processor, which is electrically connected or
20 otherwise operatively associated with a valve assembly and an inlet and outlet pressure
21 sensor assembly, so as to initially deploy, through inflation, the one or more inflatable
22 members into their operative position. The processor, valve assembly and sensor
23 assembly are operatively interactive to diffuse the force of impact caused by the occupant
24 contacting cooperatively positioned ones of the plurality of inflatable members. More
25 specifically, each of the inflatable members of the present invention actively opposes the

1 force of impact between the occupant and the inflatable member and does so
2 “intelligently” through a series of dynamic pressure measurements, made each time the
3 head, neck or torso of the occupant rocks in a “to-and-fro” motion, impacting at least one,
4 but under certain conditions, at least two substantially opposing and alternately
5 intercepting inflatable members.

6 The sensor assembly is structured to detect the pressure inside a plurality of
7 internally disposed chambers within each of the inflatable members, and to relay the data
8 relating to the internal pressure within the various chambers of each of the inflatable
9 members to the processor. The processor activates a source of inflatable material or fluid,
10 such as air, and initiates operation of the aforementioned valve assembly to provide an
11 initial inflation pressure in predetermined ones of the plurality of chambers of the one or
12 more inflatable members. The pressure within each of the inflatable members is then
13 actively regulated or adjusted to accommodate the force of impact of the occupant with
14 the inflatable member in a manner which causes both a resistance to and at least a partial
15 absorption of the force of impact. The active and “intelligent” regulation of the pressure
16 within the inflatable members serves to reduce any type of repetitive to-and-fro motion,
17 as set forth above. When two substantially opposing inflatable members are working in
18 concert, each has the internal pressure thereof actively regulated or adjusted on an
19 alternating, repetitive basis in order to reduce the to-and-fro impact motion or
20 acceleration-deceleration of the occupant, to a series of lesser motions or oscillations of
21 the head and torso.

22 Upon the vehicle being impacted, at least one of a plurality of impact sensors,
23 located on the vehicle and connected to the aforementioned processor, communicates in
24 micro-seconds, the occurrence of an impact of sufficient predetermined force to possibly

1 cause injury to the occupant within the passenger compartment. Upon such indication,
2 the processor activates also within micro-seconds a source of fluid or other inflatable
3 material and/or the valve assembly to cause an initial inflation and resulting deployment
4 of at least some of a plurality of inflatable members.

5 At least one, but preferably all, of the inflatable members comprise a number of
6 internally disposed chambers, wherein adjacent ones of such chambers are separated from
7 one another by a partition. While the actual number of chambers within each inflatable
8 member may vary, the chambers are collectively disposed and cooperatively structured to
9 define an impact absorbing zone and an impact resistance zone within each of the
10 inflatable members. For purposes of clarification, the impact absorption zone may be
11 defined by at least one, but most probably, a first plurality of internally disposed
12 chambers defining a "leading" portion of the inflatable member. The term "leading"
13 portion is meant to describe that portion of the inflatable member which first contacts the
14 head or other portion of the occupant's body. The impact resistance zone is located
15 "rearwardly" of the impact absorption zone and is defined by at least one but preferably a
16 second plurality of chambers.

17 While the inflatable restraint assembly of the present invention contemplates the
18 use of at least one inflatable member having the aforementioned impact absorption zone
19 and impact resistance zone, maximum protection to the one or more occupants may best
20 be provided through the use of at least two of the aforementioned inflatable members,
21 disposed in substantially opposing relation to one another. When such two inflatable
22 members are cooperatively positioned they each act as "interceptors" for the purpose of
23 reducing the normal, relatively excessive to-and-fro motion to lesser oscillations by
24 allowing the force of impact of the occupant onto a first of the inflatable members to be at

1 least partially absorbed, but at the same time, resisted by actively regulating the pressure
2 within the first inflatable member. At the same time, the pressure within the inflatable
3 member needed to respond to the degree of the force of impact of the occupant thereon is
4 determined. This information is then relayed, through cooperative workings of the
5 sensing assembly with the processor, to communicate the expected and/or summate force
6 of impact of the occupant onto the second or intercepting one of the cooperatively
7 positioned two inflatable members. The relayed information then allows the pressure
8 within the second of the inflatable members to be further regulated or varied to again
9 absorb the force of impact onto the second inflatable member. As will be explained in
10 greater detail hereinafter, the processor and sensor assembly are cooperatively structured
11 and operationally functional so as to arrive at a summation of the pressure within each of
12 the inflatable members and vary the total pressure so as to accomplish absorption of the
13 force of impact of the occupant by means of at least partial deflation of the impact
14 absorption zone while maintaining an opposing resistance force in the impact resistance
15 zone of each inflatable member. The summation of the pressure within any of the
16 inflatable members, should not exceed the force of impact of the occupant onto the
17 inflatable member, so as to not result in a forcible rebounding of the occupant, which
18 would add to the acceleration/deceleration or to-and-fro motion of the occupant.

19 The inflatable restraint assembly of the present invention also comprises one or
20 more cooperative pairs of the inflatable members being located strategically throughout
21 the various portions of the passenger compartment, wherein such strategic locations
22 include but are not limited to the ceiling, side or door post of the vehicle, shoulder or
23 body harness, etc. In addition, the one or more inflatable members could be mounted
24 directly on an auxiliary seat, such as a child seat, so as to be structured to operate in
25 substantially the same manner. In each of the aforementioned embodiments, one feature

1 of the present invention is that in most cases, the initial inflation and deployment of each
2 of the inflatable members does not occur in a direction that is directly towards the
3 occupant. Such directional deployment of known conventional air bags has, as set forth
4 above, in some cases resulted in severe injury to the occupant.

5 In another aspect of the invention, a system is provided for restraining occupants
6 of a motor vehicle. The system includes inflatable members mounted on the vehicle and
7 collectively positioned in substantially surrounding relation to an occupant location, a
8 fluid source connected to the inflatable members, a pressure sensing assembly disposed to
9 sense pressure of at least some of the inflatable members, impact detectors positioned to
10 detect a location of an impact between the motor vehicle and an object, and a processor
11 operatively connected to the pressure sensing assembly, the fluid source, and the impact
12 detectors. Each of the inflatable members is cooperatively structured with the fluid
13 source and the processor to inflate into an operative orientation upon instructions from the
14 processor. The processor provides instructions for selectively and sequentially inflating
15 the inflatable members in response to a detected location of an impact, and for regulating
16 pressure within the inflatable members.

17 In one aspect of the invention, sensors provide information to a processor which,
18 relying on various algorithms, look-up tables, and the like, intelligently instructs
19 responses to a system of inflatable restraints. Such responses include the selection,
20 timing and infilling pressures of inflatable members. As modern processing times are
21 generally measured in microseconds, and the forces of injury generally act in
22 milliseconds, the use of such high-speed intelligent analysis and response provides a time
23 advantage over the forces of injury.

1 In one aspect of the invention, active opposition is provided to forces of injury.
2 This active opposition to forces is accomplished by the selection of the timing and
3 infilling pressures of inflatable restraints as described below.

4 The various preferred embodiments of the present invention as described above,
5 as well as additional preferred embodiments to be described hereinafter, are intended to
6 overcome many of the disadvantages and problems associated with conventional restraint
7 systems. As with the preferred embodiments described above, the preferred embodiments
8 described hereinafter are specifically directed to better protect occupants in a motor
9 vehicle.

10 More specifically, the improved restraint assembly of the present invention is
11 based in part on a recognition of the fact that front end vehicle impacts primarily cause
12 more anterior/posterior flexion of the head, neck and the spinal column, wherein the
13 junction of the base of the spine in the low back serves as the fulcrum or point of motion.
14 This is the location where the lumbar spine fixates to the pelvis and sacrum. The spinal
15 column therefore acts as a long lever, "whipping" the head upon the neck, with or without
16 internal impacts within the vehicle. Side collisions do the same, but put the spinal
17 column, head and neck in a whipping direction of lateral flexion and rotation, from side to
18 side. Oblique impacts from either front or rear diagonal impact positions add a
19 component of rotation and angular momentum to the long lever-arm of the spinal
20 column, causing what may be generally referred to as a "conical" range of motion of
21 angular momentum of the head and neck upon the base of the spine. In further defining
22 the aforementioned conical range of motion, the base of the spine is used as or defines the
23 apex of the formed conically configured range of motion.

1 Video tape footage of dummy collision models frequently demonstrate forces of
2 both momentum and rotation, as well as the lack of adequate restraint provided by
3 diagonal seat belt (chest) restraints. Their failure to adequately eliminate the
4 aforementioned lever action of a long lever arm (the entire spinal column), causes
5 frequent severe whipping of the head on the neck, by a combination of torque,
6 centrifugal, and rotational forces, all responsible for head and neck injuries including
7 “whiplash”. Therefore, the additional preferred embodiments of the restraint assembly of
8 the present invention provides strategically and “globally” placed inflatable members,
9 which may be computerized or processor controlled. Further, the plurality of inflatable
10 members are specifically disposed to be operatively oriented relative to strategic
11 passenger positioning, as will be described in greater detailed hereinafter.

12 Further, the restraint assembly of the present invention accomplishes strategic
13 movement restriction of the spinal column, head and neck to reduce the forces of
14 deceleration, linear and angular momentum, flexion, extension and rotation through the
15 use of a plurality of inflatable members and/or a restraint harness. More specifically, in
16 certain strategic locations within a vehicle, one or more of the inflatable members are
17 deployed away from the body towards, for example the steering wheel. In this particular
18 embodiment, one or more deployed inflatable members meet and confront a cooperatively
19 disposed and structured inflatable member, issuing from the vehicle interior, such as from
20 the steering wheel, or side posts or doors, impacting air bag to air bag. Also and
21 importantly, the ventral space disposed in front of the body is reduced. This therefore,
22 serves to fill the emptiness or void into which the body has a tendency to move during the
23 type of impacts or emergency conditions described herein.

1 Other structural features of the additional preferred embodiments of the present
2 invention include adjustable belt segments of a restraining harness, such as a horizontal
3 chest belt segment thereof. The chest belt segment is operatively disposed in a
4 substantially horizontal orientation from underarm to underarm in overlying, protective
5 relation to the upper chest of the occupant. In addition, yet another structural
6 modification of this preferred embodiment may include an additional or supplementary
7 inflatable member mounted within a receptacle in the chest belt segment or other portions
8 of the harness. When deployed the supplementary or additional inflatable member
9 extends upwardly, underneath the chin area and is further dimensioned and configured to
10 extend laterally about opposite sides of the neck. Therefore, there is a reduction in the
11 forces of neck flexion and, perhaps, lateral flexion. The chest belt of the restraining
12 harness segment therefore significantly reduces the lever arm action of the spine on the
13 low back, almost to the point of elimination. Accordingly, since angular momentum is
14 proportional to the length of the lever arm which sets the head in motion, the fulcrum of
15 the lever arm is displaced from the low back to the base of the neck (C7 through T1
16 vertebrae). This makes the lever arm of the spinal column shorter. A shorter "lever arm"
17 means smaller angular momentums which are translated into reduced forces of injury or
18 possibly preventable injuries. This concept of restraint permits the possibility for using
19 smaller airbags, thereby reducing costs. The horizontal restraint houses an under chin or
20 submental airbag which restricts forward motion of the head and neck, while cushioning
21 along with a headrest airbag for the posterior neck.

22 These and other objects, features and advantages of the present invention will
23 become more clear when the drawings as well as the detailed description are taken into
24 consideration.

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 For a fuller understanding of the nature of the present invention, reference should
3 be had to the following detailed description taken in connection with the accompanying
4 drawings in which:

5 Figure 1 is a top view of a vehicle showing interior portions and the general
6 locations of plurality of cooperatively disposed inflatable members relative to an intended
7 position of an occupant within the vehicle.

8 Figure 2 is a schematic representation in partial cutaway of an occupant relative to
9 two cooperatively disposed inflatable members.

10 Figure 3 is a schematic representation of a representative one of the inflatable
11 members along with the operative components of the assembly causing its inflation and
12 pressure regulation.

13 Figure 4 is a schematic representation of the inflatable member of Figure 3 and a
14 forwardly directed impact caused by accelerated – decelerated forces acting on the head
15 and neck of an occupant.

16 Figure 5 is a schematic representation of the inflatable member of Figures 3 and 4
17 in another sequence corresponding to a rebounding movement of the occupant's head and
18 neck in an opposite, rearward direction.

19 Figure 6 is a schematic representation of one preferred location of an inflatable
20 member in accordance with the present invention.

21 Figure 7 is a schematic representation of the embodiment of Figure 6 with the
22 inflatable member in a deployed position.

1 Figure 8 is a schematic representation of another preferred location of at least one
2 inflatable member of the present invention.

3 Figure 9 is a schematic representation of the embodiment of Figure 8 with the
4 inflatable member being deployed.

5 Figure 10 is a front view of an inflatable member in accordance with the restraint
6 assembly of the present invention mounted on a restraining harness.

7 Figure 11 is a side view of the embodiment of Figure 10 shown partially in
8 phantom lines indicating a deployment of the inflatable member.

9 Figure 12 is a front view of another embodiment of the present invention wherein
10 at least one inflatable member is mounted on an auxiliary seat, such as a child's seat.

11 Figure 13 is a side view of the embodiment of Figure 12.

12 Figure 14 is a side view of the embodiments of Figures 12 and 13 shown in partial
13 phantom lines representing a deployment of the inflatable member.

14 Figure 15 is a rear view of the embodiment of Figures 12 through 14 showing a
15 deployment of another inflatable member being mounted on the side of the auxiliary seat
16 and represented in phantom lines in a deployed position.

17 Figure 16 is a side view in partial schematic demonstrating forces to which the
18 occupant is exposed in a front and rear impact accident.

19 Figure 17 is a top view in partial schematic of the embodiment of Figure 16.

20 Figure 18 is a side view in partial schematic demonstrating forces to which an
21 occupant is exposed in a side impact accident.

1 Figure 19 is a top view of the embodiment of Figure 18.

2 Figure 20 is a side view in partial schematic demonstrating forces and a range of
3 motion to which an occupant is exposed in an oblique impact accident.

4 Figure 21 is a top schematic view of the embodiment of Figure 20.

5 Figure 22 is a top view of various inflatable members strategically and globally
6 mounted within the vehicle to protect an occupant from impact forces as demonstrated in
7 Figure 16 and 17.

8 Figure 23 is a top view showing additional inflatable members which are
9 positioned within the vehicle to protect an occupant from impact forces as demonstrated
10 in Figures 18 and 19.

11 Figure 24 is a top schematic view disclosing the placement of a plurality of
12 inflatable members collectively comprising an additional preferred embodiment of the
13 present invention which protects the occupant from impact forces on the vehicle
14 encountered from a number of different directions.

15 Figure 25 is a side view in schematic form showing forces which are applied to
16 the body in an emergency condition including impacting the vehicle in which an occupant
17 is riding.

18 Figure 26 is a side view in schematic form of another preferred embodiment of the
19 restraint assembly of the present invention protecting the occupant's body from the forces
20 as explained with reference to Figure 25.

21 Figure 27 is a front view of another preferred embodiment of the restraint
22 assembly of the present invention including a restraint harness.

1 Figure 28 is a side view of the embodiment of Figure 27.

2 Figure 29 is a front view of yet another preferred embodiment of the restraint
3 assembly of the present invention.

4 Figure 30 is a top view of the embodiment of Figure 29.

5 Figure 31 is a detailed view in section showing a mounting assembly associated
6 with the restraint assembly of the embodiments of Figures 27 through 30.

7 Figure 32 is a top view of one or more belt segment structures associated with the
8 restraining harness of the embodiments of Figures 27 through 30.

9 Figure 33 is a front view of the embodiment of Figure 32.

10 Figure 34 is a top view in section and partial cutaway of yet another preferred
11 embodiment of the restraining assembly of the present invention.

12 Figure 35 is a sectional view in partial phantom of the embodiment of Figure 34.

13 Figure 36 is a side view of the embodiment of Figures 34 and 35.

14 Figure 37 is a side view of the embodiment of Figures 34 through 36.

15 Figure 38 is a front view of the embodiment of Figure 37.

16 Figure 39 is a top view of the embodiment of Figure 38.

17 Figure 40 is a front view of an interior of a vehicle showing the stored location of
18 one of a plurality of inflatable members included in the restraint assembly of the present
19 invention.

20 Figure 41 is a front view of the embodiment of Figure 40 in a different position.

1 Figure 42 is a side view in partial cutaway of the deployment of the inflatable
2 member associated with the embodiment of Figures 40 and 41.

3 Figure 43 is a side view in partial cutaway and phantom of another preferred
4 embodiment of the restraint assembly of the present invention.

5 Figure 44 is a front view of the embodiment of Figure 43.

6 Figure 45 is a side view of the embodiment of Figure 43 with an inflatable
7 member in at least a partially deployed operative orientation.

8 Figure 46 is a front view of a steering wheel associated with a vehicle in which the
9 restraint assembly of the present invention is located.

10 Figure 47 is a front view of an inflatable member associated with the steering
11 wheel of Figure 6 disposed in an at least partially deployed, operative orientation.

12 Figure 48 is a side view of the relative positions of cooperatively disposed and
13 activated inflatable members associated with the restraint assembly of the present
14 invention.

15 Figure 49 is a front view of an interior side window of a vehicle adjacent which
16 the restraint assembly of the present invention is mounted.

17 Figure 50 is a rear view of the embodiment of Figure 49 with an inflatable
18 member deployed in an operative orientation.

19 Figure 51 is a top view of the embodiment of Figure 50.

20 Figure 52 is a front view of the inflatable member of the embodiment of Figures
21 50 and 51.

1 Figure 53 is a front view of yet another preferred embodiment of the restraint
2 assembly of the present invention.

3 Figure 54 is a side view of the embodiment of Figure 53.

4 Figure 55 is a schematic representation of yet preferred embodiment of the present
5 invention relating to operational and structural features of at least one of the plurality of
6 inflatable members of the restraint assembly of the present invention with a
7 controlling/regulating, computer/microprocessor.

8 Figure 56 is a representation of a fluid conduit of the invention.

9 Figure 57 is a schematic representation of components of an alternative system of
10 the invention.

11 Figure 58 is a representation of a weight input interface in accordance with the
12 invention.

13 Like reference numerals refer to like parts throughout the several views of the
14 drawings.

15 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

16 As shown in the accompanying drawings, the present invention relates to a
17 restraint assembly designed primarily, but not exclusively, to protect occupants, generally
18 indicated as 10, within a motor vehicle, generally indicated at 12.

19 More specifically, and as shown in Figure 1, the vehicle 12 is equipped with a
20 plurality of impact sensors, as at 14, located at various positions on the vehicle, so as to
21 sense the occurrence of an impact of sufficient degree to possibly cause harm to
22 occupants within the passenger compartment 16 of the vehicle 12. The location of the

1 impact sensors 14 in Figure 1 is meant to be representative only of a plurality of locations
2 where such impact sensors 14 could be positioned, the knowledge of which is possessed
3 by persons of skill in the art relating to air bag deployment. In addition, and as shown in
4 Figure 3, the impact sensors 14 are operably connected and/or coupled to a computer
5 processor, such as a micro-processing chip or other central processing unit (CPU) 20,
6 incorporated within the vehicle 12 and responsive to the impact sensors 14 to the extent
7 of activating one or more of the inflatable members, such as 22, 24, etc., incorporated
8 within the restraint assembly of the present invention. As described below, the location of
9 sensors at, at a minimum, the front, rear, two sides, and corners of the vehicle provides
10 data which may be employed by a suitably programmed controller in the selection of
11 inflatable members for inflation and the sequence of inflation. As shown in Figure 1, an
12 inventive feature of the present invention is the strategic location of the plurality of
13 inflatable members in an operative position, relative to the plurality of intended positions
14 40 of the occupants. The intended occupant positions 40 are representative only since
15 such positions may vary depending upon the size and configuration of the vehicle.
16 Intended occupant positions 40 may also be referred to as occupant locations. It will be
17 understood that occupant location refers to the location of any part of the body of an
18 occupant; for example, restraints intended to restrain motion of an occupant's head are
19 positioned in relation to, such as forward, rearward, and to one or the other side of, an
20 occupant location.

21 With regard to Figures 1 and 2, one embodiment of the present invention includes
22 inflatable members 22 and 24 located in substantially opposing relation to one another
23 and in position relative to an occupant 10 to receive the repetitive and alternating "to-and-
24 fro" motion resulting from the occupant's head (or other portions of the occupant's body)
25 contacting a first inflatable member 22 and then, in a rebounding motion, contacting an

1 intercepting, second inflatable member 24. For example, when a vehicle is involved in a
2 head-on collision, the occupant's head 10 would initially be thrust forward and into a
3 first, forwardly disposed inflatable member, such as 22 in Figures 2, 4 and 5, and would
4 then rebound into a second, rearwardly disposed inflatable member, such as 24 in Figure
5 2. Of course, if the impact were coming from the opposite direction, the occupant's head
6 10 could initially be thrust into the rearwardly disposed inflatable member 24 and then
7 into the forwardly disposed inflatable member 22, and thus, the terms "first" and
8 "second" or "forward" and "rearward" should not be construed in a limiting sense.

9 To assume the cooperative, substantially opposing relation of the first and second
10 inflatable members 22 and 24 respectively, such inflatable members would optionally or
11 preferably be mounted in the ceiling in a collapsed, stored position maintainable by
12 pivotally attached cover members, which are forced open upon a pressurized inflation of
13 the inflatable members 22 and 24. As will be explained in greater detail, particularly with
14 reference to Figures 6 through 15, the inflatable members may be used independently of
15 one another or in cooperative relation with one another and may be mounted at a variety
16 of other strategic locations within the passenger compartment 16 in order to protect the
17 occupant 10 from an impact occurring on or to the vehicle 12 from the front, rear, side,
18 top, etc. Alternatively, the consumers may be given the option of equipping a vehicle
19 with the number of minimally protective units, or the global unit, whichever they desire to
20 purchase.

21 With primary reference to Figures 2 through 5, the structural and operational
22 features of a single inflatable member 22 will now be described. It is pointed out,
23 however, that each of the inflatable members, whether working independently of one
24 another or in cooperative relation to one another, as explained with reference to Figure 2,

1 have a substantially equivalent structure and operation. Accordingly, the inflatable
2 restraint assembly the invention of present invention comprises a fluid source 42 which
3 may include one or a plurality of sources of air, gas, gel, or other inflatable fluid material,
4 wherein each of the plurality of inflatable members, such as 22 and 24, or such as 26 and
5 28 shown in Figures 7 and 9, may be connected in fluid communication with a separate
6 fluid source or different, independent fluid sources. In addition, a valve assembly 44 is
7 operatively connected with each of the inflatable members 22 so as to regulate flow to
8 and from the interior thereof, in a manner to be described in greater detail hereinafter.
9 Also, a pressure sensing means, preferably comprising a pressure sensor assembly 46, is
10 associated with each of the inflatable members 22, 24, 26, 28, etc. in a manner which
11 serves to sense the pressure in various portions or zones on the interior thereof and relay
12 such sensed pressure to the processor or CPU 20. The CPU 20 controls and activates the
13 valve assembly 44 to actively regulate and/or vary the pressure between the various
14 portions or zones of each of the inflatable members, as will be explained.

15 Each of the inflatable members is defined by a multi-chamber construction
16 wherein, in the specific embodiment shown in Figures 2 through 5, a first plurality of
17 internally disposed chambers A, B, and C define an "impact absorption zone" which is
18 located generally on what may be termed a leading portion of the inflatable member 22.
19 A second plurality of chambers D, E, and F may define what is referred to as an "impact
20 resistance zone" and are located on a trailing portion of the inflatable member 22, relative
21 to the direction of travel or motion of the occupant 10 when engaging the inflatable
22 member 22, during an accident. It is emphasized that the number of chambers in the
23 impact absorption zone as well as the impact resistance zone may vary, and further, that
24 the number of chambers in each zone may differ from one another. The sensor assembly
25 46 is specifically structured to sense the pressure within each of the aforementioned

1 chambers A, B, C, D, E, and F and may comprise a plurality of individual sensors 49
2 connected by appropriate wiring 50 to a printed circuit board or like controller
3 mechanism (not shown) incorporated within the sensor assembly 46, which in turn, is
4 connected to the processor or CPU 20. It is to be emphasized that a variety of other
5 individual sensor structures, other than 49 may be incorporated and operative to perform
6 the primary function of sensing the pressure within each of the individual chambers A, B,
7 C, D, E, and F in relaying such sensed or determined pressure back to the controller
8 incorporated within the main body of the sensor assembly 46. Pressure sensors at outlets
9 of the anterior chambers and inlets of the posterior chambers are acceptable alternatives
10 on options to airbag wall sensors, since, in a fluid system, pressure is exerted equally in
11 all directions.

12 Each of the adjacent chambers are at least partially segregated from one another
13 by an appropriately positioned partition 52 or 53. More specifically, each of the partitions
14 52 serves to at least partially segregate the internal chambers A, B, and C of the impact
15 absorption zone and include an apertured construction in order to allow at least some fluid
16 flow there through. This embodiment serves to facilitate a partial collapse or deflation of
17 the impact absorption zone by allowing the fluid to be forced from chamber A to chamber
18 B and eventually to chamber C, where it then may flow out, from the chambers of the
19 impact absorption zone through the valve assembly 44. Conversely, the partitions 53
20 serving to separate the various internal chambers of the impact resistant zone from one
21 another, as well as the chamber C from the chamber D, do not have any type of apertured
22 construction and are, therefore, structured to define total segregation and to not permit air
23 flow to pass between the chambers D, E and F, of the impact resistance zone, for reasons
24 which will be made clear upon further description set forth hereinafter. The valve
25 assembly 44 serves to regulate fluid flow into and out of each of the internal chambers A,

1 B, C, D, E, and F and may take a variety of configurations, which are structurally and
2 operationally capable of independent flow into and out of the individual chambers A, B,
3 C, D, E, and F, as well as the selective maintenance of the pressure within certain ones of
4 the chambers and deflation of certain others of the plurality of chambers.

5 The workings of the one or more inflatable members 22, 24, etc., independently or
6 in combination with one another, and the gradient pressure differential between the
7 various internal chambers A, B, C, D, E, and F in particular, will now be explained. The
8 term "gradient pressure differential" is meant to include the difference in pressures
9 between each of the chambers of the inflatable members specifically wherein some of the
10 internal pressures of various ones of the chambers are greater than in others.
11 Accordingly, for purposes of explanation, the initial inflation pressure will be represented
12 as P_i and will also be equal to the pressure within the second plurality of chambers D, E,
13 and F, defining the impact resistance zone of each inflatable member 22. The pressure in
14 chamber A, being the first or leading internal chamber of the impact absorption zone, is
15 maintained lower than the initial inflation pressure P_i , by an increment of pressure
16 represented as (x) . Therefore, the total pressure in chamber A before the force of impact
17 of the occupant with that inflatable member may be expressed as $(P_i - x)$.

18 The pressure in chamber B will be lower than the pressure in chamber A and
19 accordingly lower than the pressure P_i maintained in chambers D, E, and F. In
20 relationship to chamber A, the pressure in chamber B will be lowered by a value (y) and
21 may be expressed as $(P_i - x) - (y)$.

22 The pressure in chamber C will be lower than that in chamber B by a value (z) .
23 Therefore, the pressure in chamber C may be expressed as $(P_i - x) - (y) - (z)$.

1 Accordingly, it should be seen that the collective pressure in chambers A, B, C, is
2 lower than the pressure P_i maintained in chambers D, E, and F.

3 In operation, the force of impact of an occupant 10 on an inflatable member 22
4 causes a transfer of pressure from chambers A to B to C, and if pressure within these
5 chambers is excessive, beyond a certain threshold point which may threaten the integrity
6 of the structure of the inflatable member 22, an out-flow of air through the valve
7 assembly 44 occurs. The sensor assembly 46 summates the transmission of pressure
8 forces, expressed as a change of pressure, while chambers D, E, and F provide initial
9 resistance to the force of impact of the occupant 10. The processor 20 then "reads" the
10 force of impact of the occupant that needs to be opposed and rapidly deploys a discharge
11 of air from the fluid source 42 to the chambers D, E, and F. As set forth above, chambers
12 D, E, and F do not communicate with one another so that disruption of the integrity of
13 one chamber, due to shear forces or tearing, will not compromise the function of the
14 entire inflatable member 22. This rapid deployment of air into chambers D, E, and F,
15 occurs in a rapid succession of increments, creates an equal and opposite force to the
16 force of impact, but not a greater force than the force of impact, so as to provide an active
17 opposition to and correction of the force of impact of the occupant. This correction
18 serves to slow the acceleration – deceleration of the occupant, as well as the occupants
19 range of motion. This, in turn, reduces the momentum upon the body part of the occupant
20 10 contacting the inflatable member 22, and further reduces successive to-and-fro
21 motions to lesser oscillations of motion of the occupant.

22 By way of further explanation, the summate pressure within the inflatable member
23 22, upon the occurrence of a first force of impact of the occupant is expressed as P_1 . In
24 terms of the pressures within the various chambers, the summate pressure P_1 is more

specifically postulated, conceptually, to be $P1 = (P_i) + (P_i - x) + ((P_i - x) - (y)) + ((P_i - x) - (y) - (z)) + E$, where E represents the external force of acceleration of the occupant. The processor 20 arrives at P1, reads the difference between P1 and the pressure P_i , and incrementally adds the amount of air needed to in-fill chambers D, E, and F, to meet and oppose this summate pressure, P1. This rapid inflation, followed by rapid deflation of the chambers D, E and F, back to pressure P_i , restores the unit to base line to receive the next impact. That summate pressure information is then transmitted by the processor 20 to the opposing, cooperatively positioned inflatable member 24 (see Figure 2), generally to the unit placed 180° opposite of the initiating unit, to provide an opposing force at least equal but not less than the previous opposing force and reduced by an increment to be determined, so that the summate pressure is not greater than the force impact of the occupant. As a result, a lower total summation pressure, P2 of the inflatable member 24 is provided as compared to P1 of the inflatable member 22. Repeated impacts will register successive summation pressures of alternating, interceptor inflatable members 22 and 24 as P3, P4, P5, etc. wherein each successive total summation pressure and opposition-corrective pressure will probably be successively lower than the preceding pressure, because of reduced inertia, active opposing pressure forces by the inflatable members 22, 24, and the coefficient of air friction, all coming into play.

With reference to Figures 3, 4 and 5, the occupant 10 engages the inflatable member 22 at a first chamber A, which is the leading portion of the impact absorbing zone. The pressure in chambers, A, B, and C begins to reduce through a transfer of air from chamber A to chamber B and from chamber B to chamber C and eventually, through the valves 60, which are now open. At this point the valves 62 associated with the chambers D, E, and F of the resistance zone are maintained in a closed position, due to activation and control by the processor 20. It should be apparent, therefore, that in

1 reaction to the force of impact of the occupant 10 with inflatable member 22, the impact
2 absorption zone will serve to absorb a portion of the force of impact while the pressure
3 within chambers D, E, and F will be initially maintained at the same pressure, P_i .
4 Therefore, chambers D, E, and F will present a resistance force, and thereby, serve to
5 define the impact resistance zone of the inflatable member 22. However, as shown in
6 Figure 5 the processor 20 "reads", through operation of the sensor assembly 46, the force
7 of impact of the occupant 10 on the inflatable member 22, and thereby, determines the
8 amount of pressure required to oppose this force of impact and incrementally increases
9 the pressures within the chambers D, E, and F of the impact resistance zone in order to
10 make the summation of forces P_1 , within the inflatable member equal to, but not greater
11 than, the force of impact of the occupant 10 engaging the inflatable member 22. In order
12 to accomplish this, the valves 60 into chambers A, B, and C are closed, whereas the
13 valves 62 are opened to allow for the immediate and rapid inflow of air for purposes of
14 the aforementioned incremental increase in pressure. This rapid deployment of air
15 discharged into chambers D, E, and F occurs in an increment to create an equal and
16 opposite force, but not a greater force than that of the force of impact of the occupant 10
17 engaging the inflatable member 22. A creation of a greater force is prohibited in that
18 such an excessive force created in chambers D, E, and F would "re-accelerate" the head
19 or other body part, possibly causing further damage or injury to the occupant 10 by
20 rebounding in the opposite direction as indicated at 64.

21 When the two or more inflatable members 22 and 24 are working in cooperative
22 relation to one another, in that they are substantially opposed as shown in Figure 2, the
23 motion indicated as 64 will be a rebounding motion. The occupant will be intercepted by
24 the second inflatable member 24, which will react in the same manner in terms of actively
25 regulating or varying the pressure in the various chambers A, B, and C of the impact

1 absorption zone, as well as the internal chambers D, E, and F, of the impact resistance
2 zone as to provide a lesser summate pressure P2, set forth above. The rebounding force
3 with which the occupant 10 engages the second inflatable member 24 will be calculated
4 almost instantaneously by cooperative workings of the sensor assembly 46 and the
5 processor 20 so as to regulate and determine the initial inflation pressure P_i of the
6 chambers D, E, and F of the impact resistance zone of inflatable member 24 and based on
7 the initial inflation pressure P_i , the pressure of the remaining internal chambers A, B, and
8 C of the impact absorption zone will also be incrementally determined and adjusted such
9 that absorption and resistance is accomplished in an optimum manner so as to reduce the
10 motion of the occupant's head, or other body part to lesser oscillations. Computer
11 software can be written to cause processor 20 to carry out the necessary calculations and
12 provide suitable instructions.

13 As shown in Figures 6 and 7, one strategic location of at least one inflatable
14 member 26 may be in an upper side corner within a compartment 26' above or adjacent to
15 a door or window opening. When inflated in the manner shown in Figure 7, the inflatable
16 member 26 will be disposed adjacent to the window, so as to protect the occupant 10
17 from impacting the window or door.

18 Similarly, in Figures 8 and 9 an inflatable member 28, including the plurality of
19 internal chambers as indicated above, may be mounted in its stored position within a door
20 post 27 and, when inflated, may extend outwardly therefrom so as to protect the occupant
21 10 from engagement with the door post, window or other portions of the door and thereby
22 reduce or eliminate lateral-flexion which causes the aforementioned injuries. In this
23 manner, a resulting rotation of the occupant 10 as indicated by directional arrow 29 may
24 also be eliminated by engagement with the deployed inflatable member 28.

1 With reference to Figures 10 and 11, at least one of the inflatable members 30
2 may be mounted on a harness 70, which extends across the occupant's body in the
3 conventional manner. The compartment 72 for the inflatable member 30 is mounted such
4 that when deployed, the inflatable member 30 is projected outwardly, away from the
5 occupant 10, when the occupant is in an intended position, such as a seat 73. The
6 inflatable member 30 once deployed may engage the steering wheel airbag generally
7 indicated as 75 or other portions of the vehicle, dependent upon the location of the seat
8 and the intended position of the occupant 10. Just as with the diagonal seat belt airbag
9 discharging forward, and away from the driver to impact, airbag-to- airbag with the
10 steering wheel airbag, similar smaller airbag units may be mounted at other locations in
11 the vehicle interior, such as sideways at both ends of the lap belt to impact, airbag-to-
12 airbag, with the window-door unit or between occupants. Airbag-to-airbag deployment
13 eliminates dead space for motion, restricts momentum and cushions the body.

14 With regard to Figures 12 through 15, the one or more inflatable members 32 and
15 34 can be mounted on and deployed directly from an auxiliary seat 80, which may be in
16 the form of a child seat or other auxiliary seat. The inflatable member 32 can be stored
17 within a harness or other component or portion of the auxiliary seat 80, as at 84, so that
18 when it is deployed it extends outwardly away from the occupant 10', as shown in Figure
19 14, into engagement with a seat back surface 75 or other portion of the vehicle, dependent
20 upon the orientation and location of the auxiliary seat 80. Similarly, a second or
21 additional inflatable member 34 can be deployed outwardly from a side area, as at 86, of
22 the auxiliary seat 80, into engagement with a side portion of the vehicle in order to
23 prevent injury from a side impact of the vehicle.

1 Figures 13 and 15 also indicate that the inflatable members 32 and 34 may be
2 electrically and/or pneumatically interconnected to the processor 20 and/or to one or more
3 fluid sources of inflatable material, such as air, by a cord or cable assembly 88, running
4 through appropriate mountings and/or apertures 89 and 90, formed on the auxiliary seat
5 80.

6 Yet additional preferred embodiments of the present invention are herein
7 demonstrated in Figure 16 through 58. As described, the restraint assembly associated
8 with these embodiments are disposed, dimensioned and structured to overcome the many
9 different types of forces to which the human body of an occupant may be subjected when
10 seated within a vehicle involved in an emergency condition. It is therefore again
11 emphasized that some injuries to an occupant are due more to linear momentum and
12 deceleration forces while others are due to angular momentums with deceleration forces.
13 In addition to these forces, the occupants may be subjected to a combination of torque
14 forces, centrifugal and centripetal forces, and "crunch" forces due to spinal loading. All
15 of these forces are summated by the time appropriate ones of the plurality of inflatable
16 members are deployed. Accordingly, most belt restraints and air bags, as known in the
17 prior art, can do little but passively absorb the forces to which the body is subjected.
18 When such summated forces are greater than the ability of the human body to tolerate,
19 tissue deformation occurs with resultant injury.

20 As shown in the accompanying drawings, and with specific reference to Figure 16
21 through 24, it is schematically demonstrated that an occupant of the vehicle generally
22 indicated as 100 and disposed in a seated position on vehicle seat 101 is exposed to forces
23 during a collision of the vehicle from both the front 102 and the rear 106. As such, the
24 spine of the occupant acts as a long lever with the fulcrum at the lumbar junction with the

1 pelvis 104. The forces influencing the body of the occupant 100 causes the large angular
2 momentum of the head on the spine with large anterior/posterior “whipping” action.
3 Forces of linear acceleration are superimposed and summated with those of angular
4 momentum and torque, wherein the linear forces are represented by the directional arrow
5 105. For purposes of reference, the occupant 100 is oriented to face in a forward
6 direction 107 and is seated next to a side or window area 108.

7 With reference to Figures 18 and 19, the spine of the occupant 100 flexes laterally
8 from side-to-side further serving to whip the head towards and away from the side
9 window 108. This is the result of an impact from a lateral or side direction such as on the
10 door or side panel 111 of the vehicle 112 as indicated in Figure 18. The phantom lines of
11 the occupant’s head indicates lateral hyperflexion from side-to-side.

12 Figures 20 and 21 represent schematic side and top views respectively for the
13 purpose of demonstrating the reaction on the occupant 100 upon the occurrence of an
14 emergency event or accident involving oblique impacts 116. Such oblique impacts
15 introduce an element of torque-rotation to the head and spine superimposed on the large
16 angular momentum forcing them into what may generally be referred to as a “conical”
17 range of motion generally indicated as 114. As such, the direction of force from the
18 oblique impacts produce the conical range of motion, wherein the apex of the conical
19 range is generally defined at the lumbosacral junction of the spine with the pelvis 104 as
20 set forth above. The head of the occupant 100 is moved through an arc of angular
21 momentum and again the forces are summated.

22 As will be explained in greater detail hereinafter, Figures 22 through 24 disclose
23 various additional preferred embodiments of the restraint assembly of the present
24 invention which are disposed, dimensioned, and configured for timely activation, by

1 operation of the processor assembly 20 and operatively associated impact sensors as at
2 14. The various components of the restraint assembly, to be described, serve to protect
3 the one or more occupants 100 from the various linear, angular or torque forces exerted
4 on the body of the occupant 100, dependent upon the direction of impact on the vehicle
5 involved in an emergency event or crash.

6 Accordingly, as shown in Figures 25 through 33 the restraint assembly of the
7 present invention comprises a restraining harness generally indicated as 120 secured to a
8 vehicle seat 101, at least in part, by a mounting assembly generally indicated as 122, to be
9 described in greater detail hereinafter. Figures 25 and 26 further demonstrate that the
10 long lever defined by the length of the spine, provides an extended whipping action
11 resulting in large angular forces of deceleration superimposed on linear forces of
12 deceleration. The summation of these forces of course increases the high tendency of
13 trauma or fatality. The increased magnitude of such forces is indicated by the extended
14 forced movement 123 of the occupant 100 in the event that an inadequate restraining
15 harness was used instead of the restraining harness 120 of the present invention.
16 However, using the restraint harness 120 of the present invention and further
17 incorporating a plurality of globally disposed inflatable members, all actuated on a timely
18 basis by the processor assembly 20, the fulcrum of motion is located at the base of the
19 neck 125, resulting in a significantly decreased arc of angular momentum 127.

20 This reduced angular momentum is directly attributable to the structuring of the
21 restraint harness 120 which includes a lap belt segment 124, an upper chest belt segment
22 126 and a diagonal belt segment 128 in a "Z" configuration when viewed from the front,
23 which deploys away from the body to reduce risk of injury. Therefore, the restraint
24 harness comprising these cooperatively structured and combined belt segments result in a

1 protection of the occupant 100 in a manner which significantly reduces the angular
2 momentum, as at 127, as well as any torque forces of the head on the neck and of the
3 chest due to a twisting action, again dependent on the direction of impact. For purposes
4 of orientation the occupant 100 is facing towards the front windshield 108' and in Figure
5 26 is represented as an operator or driver of the vehicle positioned in front of the steering
6 wheel generally indicated as 129. Harness 120 is shown in an occupant restraining
7 position in Figure 26. In general, any harness described in this application is in an
8 "occupant restraining position" when properly positioned and secured relative to an
9 intended occupant location or occupant position. The restraining harness assembly 120
10 and specifically the positioning and operation of the diagonal belt segment 128 reduces
11 lateral flexion of the spine and reduces lateral and rotational momentum towards the side
12 window 108 and the door post 109. Impact forces are further reduced and opposed by a
13 plurality of the other inflatable members to be described in greater detail hereinafter.

14 With further reference to Figures 27 through 33, the restraining harness 120 of the
15 present invention comprises the aforementioned belt segments 124, 126 and 128. As best
16 shown in Figures 27 and 28, (as well as Figure 53), the belt segments are collectively
17 oriented or disposed in a substantially "Z-shape" configuration when in their operative,
18 restraining position. In particular, Figures 29 and 30, show details of the chest belt
19 segment 126' disposable in overlying relation initially or preferably to the upper chest
20 area of the occupant 100 so as to be able to fit beneath the occupant's arms and underneath
21 the shoulders. Opposite ends of the chest belt segment 126, 126' are connected to
22 opposite or corresponding sides of the seat 101 in both the embodiment of Figures 27 and
23 29 by virtue of the aforementioned mounting assembly 122. The mounting assembly 122
24 comprises an elongated track 131, wherein each opposite end of the chest belt segment
25 126 includes an appropriately configured anchor member 132 of the type shown in Figure

1 31. The anchor member 132 is selectively positionable along the length of the track 131
2 and lockable, by interaction between the track 131 and the anchor member 132 into the
3 selected position along the length of the track 131. Both sides of the seat 101 include an
4 attachment of the mounting assembly 122 thereto, including the elongated tracks 131.

5 In addition, the chest belt 126 and/or 126' has a buckle member as at 134 secured
6 to at least one end thereof so as to facilitate removable attachment of the chest belt 126,
7 126' in the aforementioned overlying relation to at least the frontal area of the occupant
8 100. Accordingly, the anchor member 132 may be attached or connected to the belt
9 buckle such that both the belt buckle and the anchor member are movable along the
10 length of the corresponding track 131. The adjustability of the chest belt 126 is for
11 purposes of accommodating occupants 100 of varying sizes ranging from children to
12 large adults, while still providing the needed protection. Therefore, the aforementioned
13 Z-shape configuration of the belt segments 124, 126 and 128 is more specifically defined
14 by the chest belt 126 and the lap belt 124 being disposed in somewhat horizontal
15 orientation, respectively overlying the chest and lap portions of an occupant. In
16 cooperation therewith, the diagonal belt 128 extends from generally one end of the chest
17 belt 126, with which it may be connected, diagonally across the occupant to an oppositely
18 disposed end of the lap belt 124 and is preferably independently adjustable.

19 Another preferred embodiment associated with the restraining harness 120 is the
20 provision of least one inflatable member 136 mounted thereon. In the embodiments of
21 Figures 27 and 28 the inflatable member 136 is mounted, in a stored position, within a
22 chamber like structure 137. However, when inflated, as shown in Figure 26 the inflatable
23 member 136 is disposed and structured to extend outwardly away from the harness 120

1 and also away from the frontal area of the occupant 100. The one inflatable member 136
2 is further disposed in aligned relation to the steering wheel 129.

3 Accordingly, an additional inflatable member 140 may be mounted on the steering
4 wheel 129 and the inflatable members 136 and 140 are cooperatively disposed and
5 structured to be forced into confronting relation to one another to further reduce the
6 angular momentum 127 upon the occurrence of an emergency event, as described above.
7 The details of the inflatable member 140 will be discussed at greater length with regard to
8 Figures 46 through 48.

9 In addition the above, yet another feature of the present invention is the provision
10 of the one inflatable member, herein designated 136' located within the chest belt 126' ,
11 as disclosed in Figure 29. As with the embodiment of Figure 27, the activation of the
12 inflatable member 136' is such that it extends outwardly into an operative orientation
13 away from the chest belt segment 126' and the occupant 100 so as to engage a frontal
14 portion of the automobile when the occupant 100 is not the driver. Naturally, as with the
15 embodiment of Figure 26, the inflatable member 136' when inflated into its operative
16 orientation, confrontingly engages and cooperates steering wheel inflatable member 140
17 as described.

18 With reference to Figures 32 and 33, both the embodiments of Figures 27 and 29
19 may also include additional structural features which facilitate the comfort and safety of
20 the occupant 100 and eliminate any type of exposure or trauma to the chest, neck or other
21 portions of the user's body. As emphasized, injury and trauma is reduced through the
22 reduction of deceleration/momentum of upper body forward motion, thereby reducing
23 deceleration of the head and neck. To accomplish this, one or more of the belt segments
24 124, 126, 126' and 128 may include an inflatable section generally indicated as 142. The

1 inflatable section 142 extends outwardly from the surface 144 which confronts the
2 occupant (not shown) and may comprise at least one, but preferably, a plurality of
3 inflatable air chambers 145 of sufficiently reduced dimension to be mounted on one or
4 more of the belt segments. The air chambers 145 are disposed substantially on the
5 interior of the various belt segments, collectively indicated as 150 in Figure 33 for
6 purposes of clarity. The one or more air chambers 145 are inflatable upon a sensing
7 assembly 14 determining the existence of an emergency event or impact and also
8 substantially concurrently to the inflation of the remaining inflatable members of which
9 the restraining assembly of the present invention is at least partially comprised.

10 With reference to Figures 34 through 39, yet another preferred embodiment of the
11 present invention comprises structural modifications of the harness assembly 120, and
12 more specifically, the chest belt segment 126, 126'. In situations where the inflatable
13 member 136 is mounted in the diagonal belt segment 128, the chest belt segment 126,
14 126' may include an additional inflatable member generally indicated as 142. The
15 inflatable member 142 is mounted within an area or compartment 144 having a
16 removable cover member 143. The cover member 143 is disposed in covering or closing
17 relation to the chamber 144 when the inflatable member 142 is in its stored position. As
18 stored, the inflatable member 142 includes two outwardly extending lateral or end
19 portions 145 disposed in folded or overlapping relation to a central portion 146. The
20 lateral or end portions 145 are folded into the overlapped position along designated fold
21 lines 147 and 147' as indicated in Figures 37 and 38. The cover member 143 may pivot
22 outwardly or be displaced in any other applicable direction relative to connection 143' in
23 order to allow the inflatable member 142 to extend outwardly from the chamber 144 into
24 an inflated, operational orientation as shown in Figures 36 through 39.

1 First, and with reference to Figure 36, upon activation, the closure 143 is opened
2 or displaced and the inflatable member 142 extends outwardly into its inflated, operable
3 orientation. As shown in Figure 37, the inflatable member 142 is such as to extend in
4 front of the neck or throat area 100' of the occupant 100 immediately beneath the chin
5 area 149. Further, the lateral or end portions 145 are dimensioned, configured and
6 disposed relative to the central portion 146 to extend in overlying, protective relation to
7 opposite sides of the throat or neck, as clearly demonstrated in Figures 37 through 39.
8 Accordingly, when in its fully inflated position the throat and sides of the neck are
9 completely protected as the inflatable member 142 wraps laterally around the throat and
10 neck to reduce both forward and side flexion forces of the head on the neck. In order to
11 accomplish the proper deployment and orientation of the inflatable member 142 when in
12 its fully extended, operational orientation, the inflatable member 142 may be formed of a
13 plurality of internal chambers which are concurrently inflated such that the inflatable
14 member 142 assumes its protective position almost instantaneously.

15 As set forth above, additional preferred embodiments of the restraining assembly
16 of the present invention comprise the global positioning, relative to the occupants and the
17 interior of the vehicle, of the plurality of inflatable members. With reference to Figures
18 41 through 44, such inflatable members may include ceiling members mounted on the
19 upper portion of the vehicle adjacent the ceiling and in a variety of different locations. At
20 least some of the locations of the ceiling members, is the provision of cooperatively
21 disposed anterior and posterior members designed to restrict motion and momentum of
22 both the front portion and the rear portion of an occupant's head. The ceiling members
23 are disposed and structured to cooperate with others of the plurality of inflatable
24 members, as well as the restraining harness, but also optionally or independently thereof
25 if desired.

1 As shown in Figure 26, the ceiling members include the anterior ceiling member
2 154 and the posterior ceiling member 156. The anterior ceiling member 154 is preferably
3 mounted, in at least one embodiment of the present invention, in a compartment 157
4 located adjacent to and preferably behind the sun visor or like structure 158 as best shown
5 in Figures 41 through 42. When activated into an inflated, operational orientation, the
6 sun visor 158 is forced downwardly, either by the outwardly directed force of the
7 inflatable anterior member 154 or by activation of a drive motor 159. In either case, upon
8 activation of the anterior ceiling member 154 the sun visor 158 is forced downwardly in
9 accordance with the directional arrows indicating the position of Figure 41. The
10 inflatable anterior ceiling member 154 will be deployed outwardly as shown in Figure 42
11 to engage the frontal area of the head and face of the occupant 100. Also, the visor 158,
12 in at least one embodiment, will serve as a support foundation or the like, and offer
13 adequate or applicable resistance to the outwardly extended operational orientation, when
14 inflated, of the inflatable member 154.

15 In addition, and in cooperation therewith the inflatable posterior member 156, as
16 indicated in Figure 26, may be located in a head rest, generally indicated as 160 and
17 mounted on the upper peripheral portion or end of the car seat 101 as at 101'. With
18 primary reference to Figures 45 through 45, the head rest 160 may include an interior
19 chamber and a padded or cushioned cover member 161 disposed in overlying, closing
20 relation thereto. As shown in Figure 43 the cover member 161 is movable, upon
21 activation of the inflatable member 156' from the closed position to the open position.
22 Upon opening, and upon inflation the inflatable member 156' will extend outwardly away
23 from the head rest 160 so as to engage and protect as well as absorb forces from a
24 deceleration 163 of the head of the occupant 100 as best shown in Figure 45.

1 With primary reference to Figures 46 through 48 and as set forth above, the
2 plurality of inflatable members of the restraining assembly of the present invention
3 further comprises a steering wheel member 140. The steering wheel member 140 is
4 located, when in its stored position, within a chamber 166 having an appropriate cover or
5 lid 167. When activated, the inflatable steering wheel member 140 extends outwardly
6 from the exposed face of the steering wheel 129 through an opening in the retaining
7 chamber or compartment 166 and after the closure 167 has been displaced from its
8 covering position. As best shown in Figures 47 and 48 the steering wheel inflatable
9 member 140 preferably comprises a flat, somewhat circular or round configuration.
10 Moreover, the diameter or transverse dimension of the inflatable steering wheel member
11 140 is somewhat greater than that of the steering wheel 129. This will prevent the
12 occupant 100 from impacting with any portion of the steering wheel 129. Also, the
13 substantially flat configuration of the steering wheel member 140 preferably is defined by
14 a depth or width of approximately 2 to 3 inches. This of course significantly differs from
15 prior art air bags which issue from the steering wheel, and deploy toward the passenger
16 with force.

17 The flattened configuration of somewhat limited width or depth, as set forth
18 above, is permissible since the steering wheel member 140 is designed to cooperate with
19 and confrontingly engage the inflatable member 136 which extends outwardly from the
20 diagonal restraining harness 120. The inflatable member 136 is disposed in aligned,
21 confronting relation to the steering wheel member 140, whether the member 136 is
22 extended outwardly from the diagonal belt segment 128 or the chest belt segment 126.
23 Therefore, the purpose of the steering wheel member 140 and its cooperative relation to
24 the inflatable member 136, associated with the harness assembly 120, is to reduce risk of
25 blunt trauma to the chest and abdomen, or other frontal area portions of the occupant 100

1 by acting as a buffer between the occupant 100 and the steering wheel 129. It is
2 important to note that one feature of the present invention is the outward extension of the
3 inflatable member 136 away from the harness assembly 120 and also away from the
4 frontal area of the occupant 100. Therefore the steering wheel member 140 and the
5 harness inflatable member 136 cooperatively oppose, in summation effect, the angular
6 momentum of the head/neck/body due to deceleration, reducing the impact forces on the
7 chest, abdomen, and other frontal area portions of the occupant 100. Optionally, an under
8 steering column airbag unit may be placed to deploy downward to protect the pelvis and
9 legs.

10 With reference to Figures 49 through 52, yet another preferred embodiment of the
11 present invention comprises the plurality of inflatable members, being activated through
12 operation of the CPU or processor assembly 20, as set forth above and further including a
13 side or window inflatable member generally indicated as 170. The inflatable member 170
14 is disposed above or beneath or otherwise substantially adjacent to the window or side
15 portion 108. As such, when in its stored position, the inflatable member 170 is disposed
16 within a compartment 172 having an appropriate closure or cover member 173. Once
17 activated, the inflatable member 170 issues from the chamber 172 once the cover 173 has
18 been displaced.

19 The dimension, configuration and disposition of the inflatable member 170 is such
20 that it protects the side, head, neck, etc. against side injuries due to lateral flexion/rotation
21 of the occupants body. In order to accomplish this, and as best in shown in Figure 52, the
22 inflatable member 170 has a sectional or a segmented construction. The segmented
23 structure includes a central portion 174 which extends outwardly into an operational
24 orientation when inflated so as to engage primarily the head area or lateral portion of the

1 head. In addition, the inflatable member 170 includes an outer, substantially surrounding
2 peripheral portion 176 disposed in spaced relation to the central portion 174, wherein the
3 separating space 178 also has a substantially annular configuration. Accordingly, it is
4 readily apparent that the inflatable member 170 is somewhat dish-shaped and generally
5 similar to a round shield-like structure. As such, the central portion 174 provides extra
6 protection or buffering against side impacts of the vehicle. The surrounding peripheral
7 portion 176 folds in overlapping relation to the central portion 174 in accordance with the
8 provision of a plurality of fold lines or creases appropriately formed on the inflatable
9 member 170. The folding, overlapping relation of the various parts 174 and 176 relative
10 to each other and to the open surrounding space 178 is of course accomplished when the
11 inflatable member 170 is in its stored position, as set forth above.

12 Yet an additional feature of the present invention is the structural adaption of a
13 plurality of the embodiments, as set forth above, to a vehicle seat 180 which may be
14 considered a rear seat or be located within the vehicle at various locations depending on
15 the size and capacity of the vehicle. As such, the seat 180 includes a plurality of seat
16 locations. Each seat location is equipped with a harness assembly 120 and is disposed in
17 association with appropriately disposed inflatable members 136. As with the embodiment
18 of Figures 27 and 28, each of the restraining harness assembly 120 of each seat location
19 comprises the lap belt segment 124, the chest belt segment 126 and the diagonal belt
20 segment 128 collectively oriented or disposed in the aforementioned "Z-shape"
21 configuration, wherein the lap and seat belts 124 and 126 are substantially horizontally
22 oriented and the diagonal belt segment 28 extends from one end 126 diagonally across the
23 area to be occupied by a passenger to an opposite end of the lap belt 124. In addition, the
24 ceiling inflatable members may include a posterior member 156" mounted, when in its
25 stored position, in a head rest built in to an upper portion of the seat as at 182.

1 Again with reference to Figures 22 through 24, the plurality of inflatable members
2 which define the restraint assembly of the present invention further includes a side
3 member 113. The side member 113, when in a stored position is disposed in an
4 appropriately located chamber and positioned substantially adjacent the outer shoulder of
5 an occupant 100. Upon the occurrence of an emergency event the side member extends
6 outwardly into engagement with a shoulder, arm or other lateral portion of the occupant
7 100 to further protect against trauma and provide a buffer against side and/or oblique type
8 impact.

9 It is again emphasized that in the most preferred embodiments the plurality of
10 inflatable members are each connected to some type of fluid source and are cooperatively
11 structured therewith so as to be almost instantaneously activated and thereby inflated
12 outwardly or in the indicated direction into an operational orientation so as to protect the
13 one or more occupants within the vehicle. Further, the fluid source, and at least some of
14 the inflatable members are controlled in the most preferred embodiments by the
15 aforementioned processor assembly 20, which is responsive to the one or more impact
16 sensors 14, as well as the valve assembly and pressure sensor assembly 46 described in
17 detail with regard to Figures 1 through 15. The infilling pressure generated by the
18 inventive assembly is ideally determined generally by the weight of at least a person's
19 head and speed of the vehicle, which are inputted and/or monitored by the computer
20 processor and communicatively integrated within the assembly, such that it is structured
21 to initiate a safe in-filling of fluid to respond to injury forces without being the cause
22 itself of injury forces, thus providing an "intelligent" instantaneous computerized
23 response. Because of computer monitoring of car speed continually, airbag filling
24 pressures will vary with speed but will be maintained within physiological limits, so that
25 risk of injury from airbag pressure is minimized or nearly eliminated.

1 With reference to Figure 55, yet an additional preferred embodiment of the
2 present invention relates to an alternate construction and operation of at least one of the
3 plurality of inflatable members associated with the restraining assembly of the present
4 invention. The in-filling dynamics of the air bag as shown in Figure 55 is regulated, at
5 least in part, by a computer/microprocessor and various sensor assemblies that may be
6 strategically mounted on or otherwise associated with the vehicle. However, and as also
7 shown in Figure 55 the indicated computer/microprocessor takes into consideration the
8 speed of the vehicle at the time of an accident or impact and processes such data along
9 with physical characteristics of the occupant or passenger. Such physical characteristics
10 include the weight of the occupant which in turn may be determinative of the mass/weight
11 of the occupant's head. Further, this embodiment may include the provision of some type
12 of weight scale, preferably associated with the vehicle itself. The weight scale as well as
13 other sensor assemblies, such as those shown in Figure 55, may communicate directly
14 with the computer/microprocessor. Therefore pertinent data is associated and processed
15 such as, but not limited to, the speed of the vehicle, the weight of the passenger and the
16 mass/weight of the passenger's head which, anatomically is generally about 7% of body
17 weight. This data, once properly processed will in turn be at least partially determinative
18 of the in-filling dynamics of the one or more inflatable members, of the type shown in
19 Figure 55 being regulated by the computer/microprocessor and the data received from one
20 or more of the associated sensor assemblies as disclosed.

21 As will be appreciated, in the system of the invention, conduits are provided
22 between a source of pressurized fluid and each inflatable member. The source of
23 pressurized fluid may be one or more liquid generating systems located in the
24 automobile. The conduits are preferably permanently open, so that the conduits do not
25 require the fluid pressure for inflation. In order to obtain a relatively large cross-sectional

1 area, a relatively wide and low or flat profile is desirable. For example, the conduit may
2 be between 2 inches and 2.5 inches in width and about 0.25 to 0.375 inches in height.
3 This permits them to be placed under the floor, in the roof of the passenger compartment and
4 in the side walls above and below the doors. The conduits may be made of a flexible
5 sheet material substantially impervious to the fluid and reinforced with substantially rigid
6 ribs. The substantially rigid ribs may be any suitable material, such as a metal, plastic or
7 composite wire in a spiral formed into the desired shape. Referring to Figure 56, there is
8 shown an exemplary section of conduit 205 with skin 210 of a flexible sheet material.
9 Skin 210 is shown in partial cutaway to reveal ribs 215 formed in a generally spiral
10 configuration. The wide, flat configuration permits the movement of large volumes of air
11 quickly.

12 In a system of the present invention, a variety of data is obtained and provided to
13 one or more data processors for the purpose of controlling the selection, timing, inflation
14 speed and air pressure in inflatable restraints in a vehicle. Data useful to the system
15 includes the speed of the vehicle, the location on the vehicle of the impact, and the weight
16 of the occupants, and more specifically the weight of the head of each occupant.
17 Referring to Figure 57, there is shown a block diagram depicting processor/memory 20
18 and various sources of data, including impact sensors 14, weight data interfaces 220,
19 velocity sensors 225, and pressure sensors 49. Occupant presence detectors 221, in the
20 form of weight or pressure sensors located in the vehicle seats, may provide an indication
21 as to whether an occupant is located at each intended occupant location in the vehicle but
22 are preferably not used to determine total body weight. Control signals are provided to
23 fluid flow control in the form of valve assemblies 44.

1 The weight of each occupant and the weight of the head of each occupant may be
2 obtained in a variety of means. The weight of the head of an adult is typically within a
3 range of the percentage of the total body weight of the adult. The range is in the
4 neighborhood of seven percent of the weight of the adult. The weight of the adult can be
5 obtained, and then the weight of the head can be calculated by a suitable algorithm. One
6 means of obtaining weight information is by obtaining the information from the
7 individual, without the need for weight sensors. For example, an interface may be
8 provided within the automobile to prompt the input of the weight of the driver and each
9 passenger by location. The interface is under the control of a programmed controller.
10 This controller may be separate from processor 20, or control of the interface may be
11 under processor 20. The interface may include an alphanumeric display and one or more
12 input devices, such as a keypad, touchscreen, or screen that senses contact with a stylus.
13 The interface may prompt an input of the location of the driver or passenger. For
14 example, keys may be provided for each driver and passenger location. A diagram of the
15 passenger compartment of an automobile may be superimposed with keys at the
16 locations. After the location of the driver or passenger is input, the controller may cause
17 the interface to prompt for input of the person's weight. A numeric keypad, for example,
18 may be provided for an input of the person's weight. When the weight is received, the
19 display may prompt confirmation of the received data, and acknowledge receipt of the
20 data. Sensors may be located in the passenger seats to detect the presence of a passenger.
21 These sensors may provide information to the controller, which will prompt for an input
22 of a weight as to each seat that is detected as occupied. Referring to Figure 58, an
23 exemplary display 250 with input keypad 255 is shown. The display and keypad may be
24 located on the instrument panel of the vehicle. Display 250 has an indication 260, 261,
25 262, 263, 264 for each seat, and which show, based on data from a sensor in the seat, as to

1 whether the seat is occupied, as provided by indicators 260, 261 for the front seats, or
2 vacant, as provided by indicators 262, 263 and 264 for the rear seats. For each occupied
3 seat, in this case the front seats, the user is prompted to input the occupant's weight using
4 keypad 255. A flashing cursor may be used as a prompt, and input keypad 255 may
5 include keys to permit navigation through the seat indications 260 of display 250. Other
6 variations may be employed. For example, rather than a need to provide the passenger
7 weight at each time that the vehicle is started or a passenger enters the vehicle, the
8 programmed controller may store the weights of a list of frequent drivers and passengers
9 associated with name information. Name information may then be entered in lieu of
10 weight information. Weight sensors may also be provided. For example, weight sensors
11 may be provided at various locations in the vehicle, such as in the lower part of the door
12 opening. The occupant will, for example, stand on the door edge or a running board to be
13 weighed. Occupants may be prompted by the aforementioned display to step on one of
14 the sensors for a sufficiently long time that the weight of each of the occupants may be
15 obtained. The weight information may be stored in a memory device that may be
16 accessed by the processor.

17 The vehicle speed may be provided to the processor by receiving motion data
18 from the axles. The data may be the same data employed by a conventional speedometer,
19 or may be obtained by one or more separate sensors. The vehicle speed data may be
20 stored in a memory device that may be accessed by the processor. The vehicle speed data
21 is preferably updated.

22 Information as to a point of impact may be obtained from impact sensors
23 distributed at various locations on the perimeter of the vehicle. A variety of technologies
24 are known for serving as impact sensors. These sensors may be provided at least in the

1 front, each side, and rear, and may be distributed at intervals around the vehicle for
2 greater sensitivity as to point of impact. Exemplary sensor locations are shown, as noted
3 above, at 14 of Fig. 1. Sensors such as vibration sensors and pressure distortion sensors
4 may be employed.

5 In the event of an impact between the vehicle and an object external to the vehicle,
6 the following events occur. The receipt of a signal from one or more sensors commences
7 the process of selecting the proper inflatable restraints, the sequence of inflation, and the
8 pressure of inflation. A guiding principle is that the first impact between the occupant
9 and the interior of the vehicle will occur generally between the location of the occupant
10 and the location of the impact. This first impact between the occupant and the vehicle
11 interior is frequently known as the "coup." The controller is programmed to cause the
12 inflation of one or more restraints located generally intermediate each occupant and the
13 detected location of the impact between the vehicle and an object external to the vehicle.
14 A look up table may be provided to identify the one or more restraints to be inflated upon
15 detection of impact at a particular sensor for each passenger and the driver. The speed of
16 inflation is controlled by the controller's operation of the valves. The pressure is
17 designed to counteract the force of the body and head of the individual. The force
18 required is simply give by $F=ma$, where the mass is the mass of the body and the
19 calculated mass of the head, and the acceleration is determined from the speed of the
20 vehicle and an appropriate amount of time for the body or head to come to zero velocity
21 relative to the restraint after colliding with the restraint. The magnitude of the
22 acceleration may be based in part on vehicle velocity data obtained after the impact
23 between the vehicle and an external object and correlated with time.

1 The controller is also programmed to inflate one or more restraints located
2 opposite the initially-inflated restraints. The need for inflation of these restraints is
3 required because, as discussed above, there is a second impact between the driver or
4 passenger, or the head of the driver or passenger, subsequent to the first impact. This
5 second impact is known as the "contra-coup." The timing of inflation of the opposite
6 restraints is determined based on the velocity at the time of impact. The inflation of the
7 restraints is thus sequential. The restraints intermediate the occupant and the location of
8 the vehicle impact are inflated first. The restraints opposite the first-inflated restraints are
9 inflated next.

10 The foregoing principles will be illustrated with examples. In a first example, a
11 vehicle is proceeding forward at a velocity detected by a speedometer when an impact is
12 detected at the front center of the vehicle. The controller selects restraints in front of the
13 driver and each passenger based, for example, on a look-up table associating sensor data
14 with appropriate restraints. The rate of inflation and desirable pressure within the inflated
15 restraints will be selected based on the required force, which is based on the mass of the
16 individual's head and the total body mass, taking into account speed at the time of impact
17 and deceleration. The details of the algorithms may be determined by those of ordinary
18 skill in the art. In general terms, for a given restraint, the greater the total body mass, the
19 speed at impact, and the deceleration rate, the greater the force required, and hence the
20 greater the inflation rate. Referring to the locations of restraints in Fig. 26, anterior
21 ceiling restraint 154, belt restraint 136 and steering wheel restraint 140 are activated first
22 in the event of an impact at the front center of the vehicle. Restraints illustrated at 156,
23 located to the rear of the occupant's head, are inflated at a selected time after inflation of
24 the forward restraints. The time of inflation of restraint 156 is selected to receive the
25 occupant's head after the initial impact with the anterior ceiling restraint 154. In this

1 way, infilling airbag pressures are physiologically determined and selected for each
2 occupant based upon speed or acceleration and body weight.

3 If the impact between the vehicle and an object is detected at the rear of the
4 vehicle, the processor will instruct inflation initially of restraints to the rear of the
5 occupant location. By way of example, a headrest restraint, such as that shown at 156' of
6 Fig. 24 is inflated. The inflation rate and pressure are calculated based on suitable
7 algorithms from occupant body weight. Vehicle acceleration must also be factored into
8 the calculation of the desired pressure. Subsequent to inflation of the headrest restraint
9 156', one or more restraints located opposite or generally opposite to the headrest
10 restraint may be inflated. For example, forward ceiling restraint 154 may be inflated
11 subsequent to inflation of headrest restraint 156'. The occupant's head initially moves
12 rearward relative to the vehicle interior and impacts inflated headrest restraint 156'. The
13 occupant's head then rebounds and moves forward to impact forward ceiling restraint
14 154, which has been subsequently inflated. Because of the ability of the z-belt to reduce
15 the long lever action of the spine on the pelvis and to reduce momentum, the sizes of the
16 airbags of this various units can be much smaller than conventional units, and will reduce
17 production costs.

18 In another example, a vehicle is proceeding forward at a speed detected and
19 provided to the controller when an impact is detected near one side of the vehicle at the
20 front. Such an impact results in motion of the occupants in a rotational pattern relative to
21 the vehicle interior. Such a rotational motion is illustrated by way of example in Fig. 20
22 and 21. The rotational motion of Figs. 20 and 21 is characteristic of an occupant after an
23 impact at the front right side of the vehicle. The sequence of restraint inflation is design to
24 anticipate this rotational motion. By way of example, referring to Fig. 24, side forward

1 restraints 170 and forward ceiling restraints 154 are inflated. These restraints may be
2 inflated simultaneously. The occupant's head impacts restraints 170 and 154. The
3 occupant's head may impact forward restraint 154 more than once, as the illustrated
4 forward ceiling restraint has a concave surface, and the occupant's head is moving in a
5 rotational pattern. Body restraints, such as belt mounted restraint 136 and steering wheel
6 mounted restraint 140 may also be inflated simultaneously with ceiling restraint 154.
7 Subsequent to the inflation of the side forward restraints 170 and forward ceiling restraint
8 154, a rearward restraint, such as rear ceiling restraint 156 is inflated. If the pressure
9 detected from the rear ceiling restraint 156 is consistent with continued rotational motion
10 of the occupant, then the side airbag 170 will be inflated again. The inflation of
11 appropriate restraints will continue under control of the processor 20 until the pressure
12 detected is sufficiently low to indicate that the motion of the occupant's head has ceased.

13 The selection of restraints for inflation may be determined based in part on speed
14 of the vehicle at the time of impact of the vehicle and any detected subsequent speed. For
15 example, if the vehicle is moving forward at low speed, and an impact is detected at the
16 front of the vehicle, the selection of restraints may be fewer than those activated when an
17 impact is detected at high speeds. In such an impact, the only restraints activated may be
18 those forward and to the rear of the occupant location, and not window or side restraints.
19 The speed of inflation and the desired pressures detected by the pressure sensors will be
20 relatively low if the vehicle speed at the time of impact is relatively low. Alternatively, if
21 an impact is detected when the vehicle speed is relatively high, all of the available
22 restraints for each occupant location at which an occupant is detected may be inflated in a
23 sequence and with pressures regulated by the processor. Infilling speeds and pressures
24 will be relatively higher. A suitable algorithm may be developed by those of skill in the
25 art which relates vehicle speed at the time of impact to infilling flow rate and desired

1 pressure. In general, infilling flow rate and pressure will increase as vehicle speed at the
2 time of impact increases.

3 A memory device associated with the processor preferably records the data
4 received by the processor and the sequence of inflation and deflation of restraints under
5 the control of the processor. Review of such memory data and examination of and
6 interviews with occupants will permit refinement of look-up tables and algorithms for use
7 by the processor.

8 Since many modifications, variations and changes in detail can be made to the
9 described preferred embodiment of the invention, it is intended that all matters in the
10 foregoing description and shown in the accompanying drawings be interpreted as
11 illustrative and not in a limiting sense. Thus, the scope of the invention should be
12 determined by the appended claims and their legal equivalents.

13 Now that the invention has been described,